Soil organic carbon storage in a no-tillage chronosequence under Mediterranean conditions

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INTRODUCTION

• In Mediterranean conditions, reductions in tillage intensity ***increase soil organic carbon (SOC) levels*** (e.g., Murillo et al., 2006; Virto et al., 2007; Hernanz et al., 2009)

• For the overall dryland Spain, mean SOC sequestration rate was estimated in ***0.23 Mg ha^{-1} yr^{-1} (0.01-0.46 Mg ha^{-1} yr^{-1})*** (Álvaro-Fuentes and Cantero-Martínez, 2010)

Several factors:

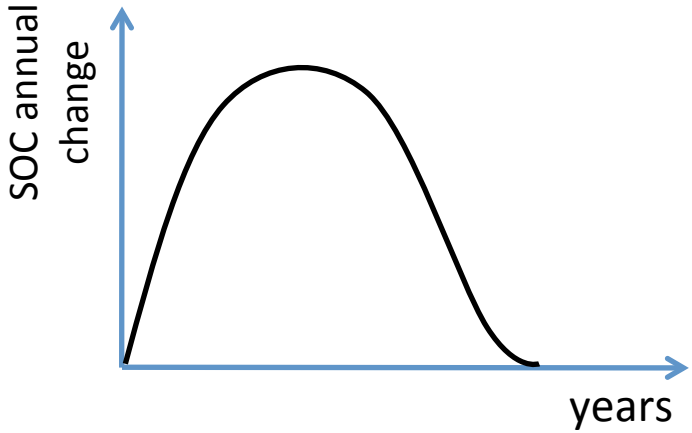
- Sampling depth
- Climate
- Soil type
- Management
- …

SOC gain?

SOC gained (Mg ha^{-1}) = SOC seq. rate (Mg ha^{-1} yr^{-1}) x SOC seq. duration (yr)

Limited information in Mediterranean conditions

- SOC gain is a ***temporal dynamic process***



(West and Post, 2002)

- Maximum gain at 5-10 years.
- Sequestration duration about 15-20 years

Objective:

To study both the ***temporal dynamics*** and ***duration*** of the ***SOC sequestration*** after the adoption of ***no-tillage*** (NT) under Mediterranean conditions

↓

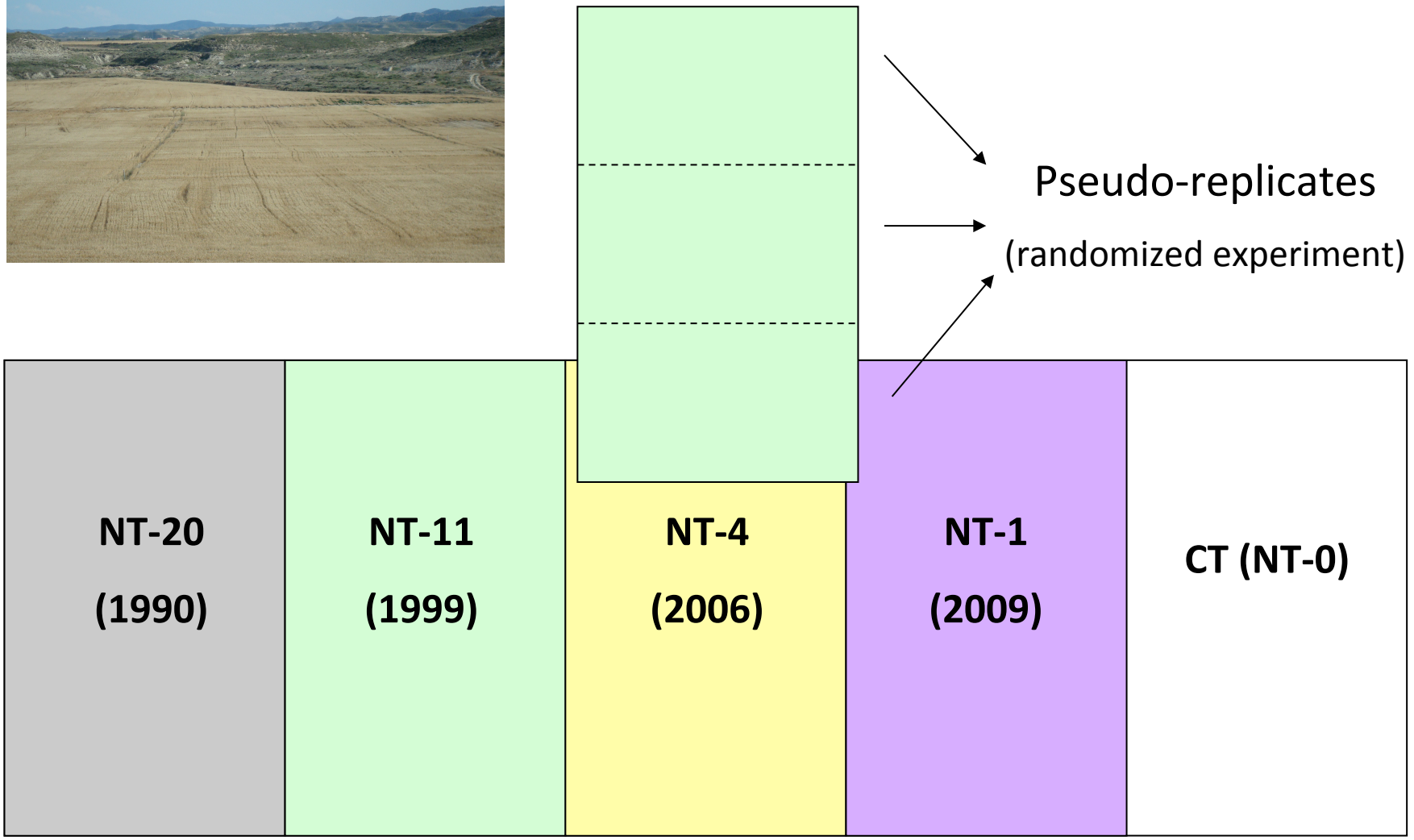
NT ***chronosequence*** established 20 years ago in northeast Spain

Lleida, Spain

- Annual precipitation: 430 mm
- Soil texture: clay 16%; silt 53%, sand 29%
- Dryland continuous wheat or barley

Representative Mediterranean conditions

NT Chronosequence



Measurements (2010)

- SOC concentration (0-5, 5-10, 10-20, 20-30 cm)
- Soil bulk density

- SOC content corrected for equivalent soil mass (ESM)

- Change in the annual amount of SOC sequestered (%_change)

$$\%\_\text{change} = \frac{\frac{\left(SOC\_NT_t - SOC\_CT_t\right) - \left(SOC\_NT_{t-x} - SOC\_CT_{t-x}\right)}{\left(SOC\_NT_{t-x} - SOC\_CT_{t-x}\right)}}{years} x\ 100$$

- Cumulative change in SOC sequestered

Modelling

- Century model (Parton et al. 1987)

- Initial distribution of SOC pools:

  1) Equilibrium: tree-grass system, 30 years fire frequency, 7000 years

  2) Base (150 years): wheat monoculture, intensive tillage and 10 kg N ha^{-1} as pig slurry during the first 100 years and 30 kg N ha^{-1} during the last 50 years

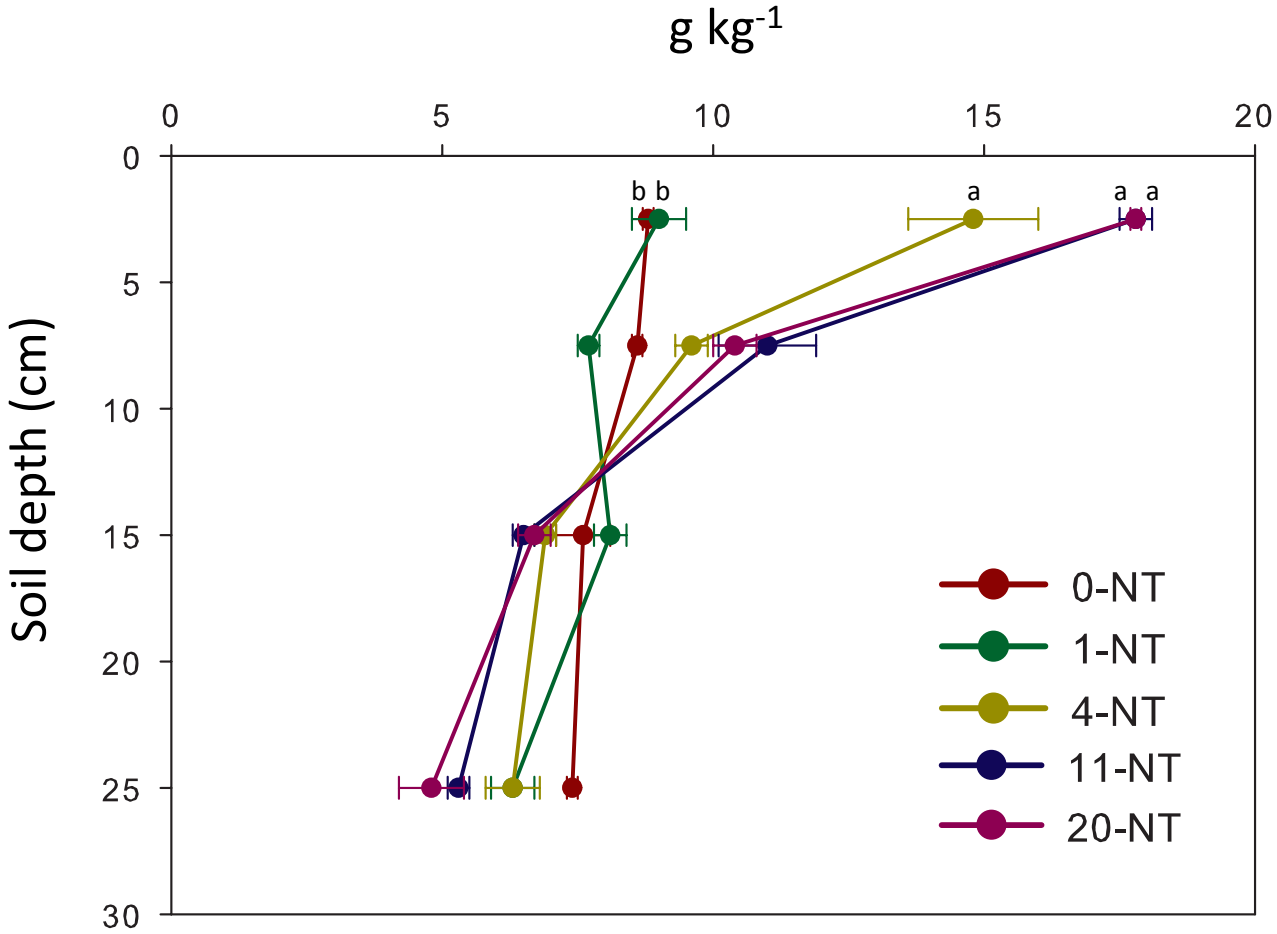
- Parameterized to simulate in the 0-30 cm soil layer (Metherell et al., 1993)

  1) Lower decomposition rates

  2) Older soil carbon dates

RESULTS

- SOC concentration



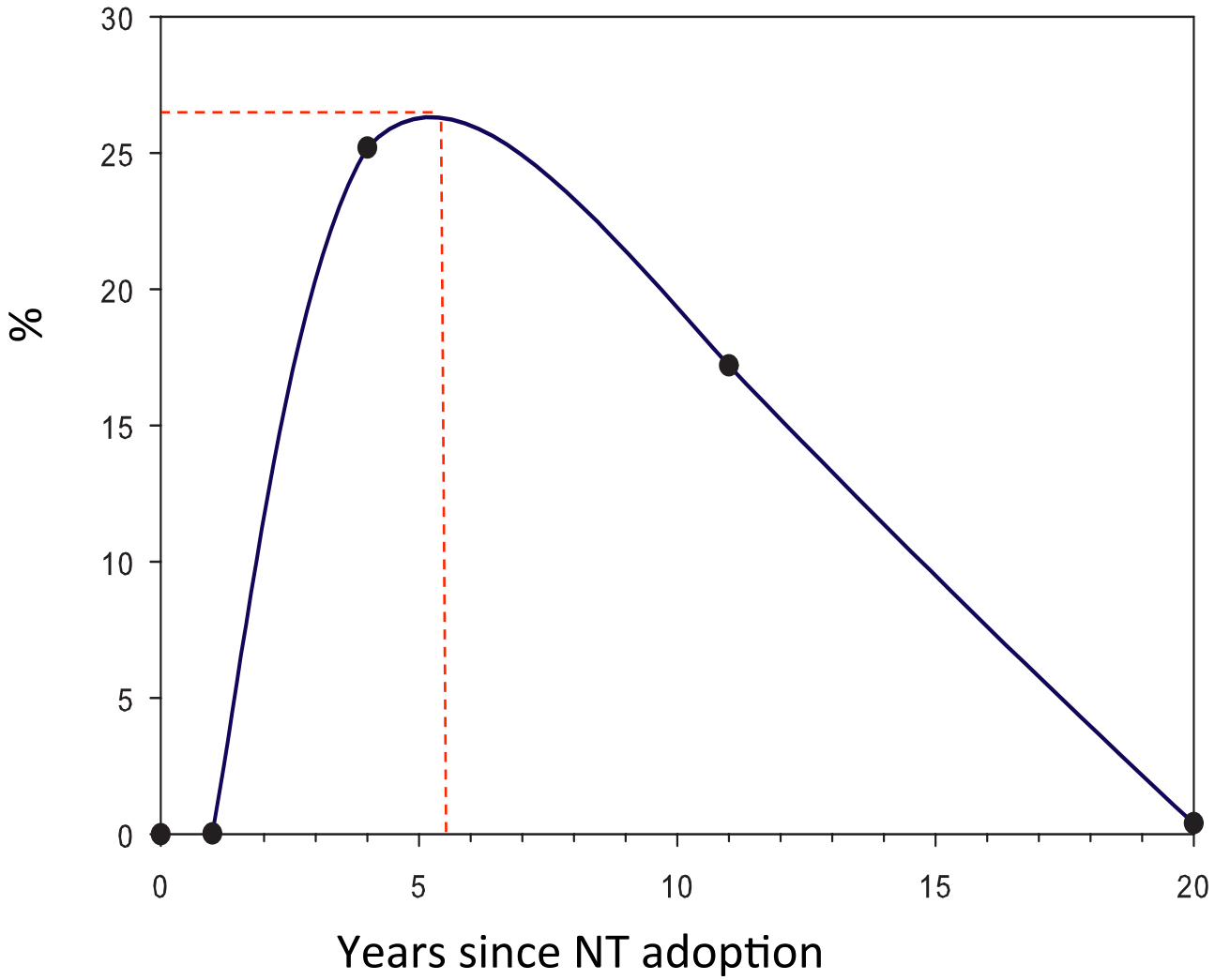
Means followed by the same lowercase letter within a depth are not statistically different at P ≤ 0.05 according to Tukey´s HSD mean separation test.

- SOC stocks

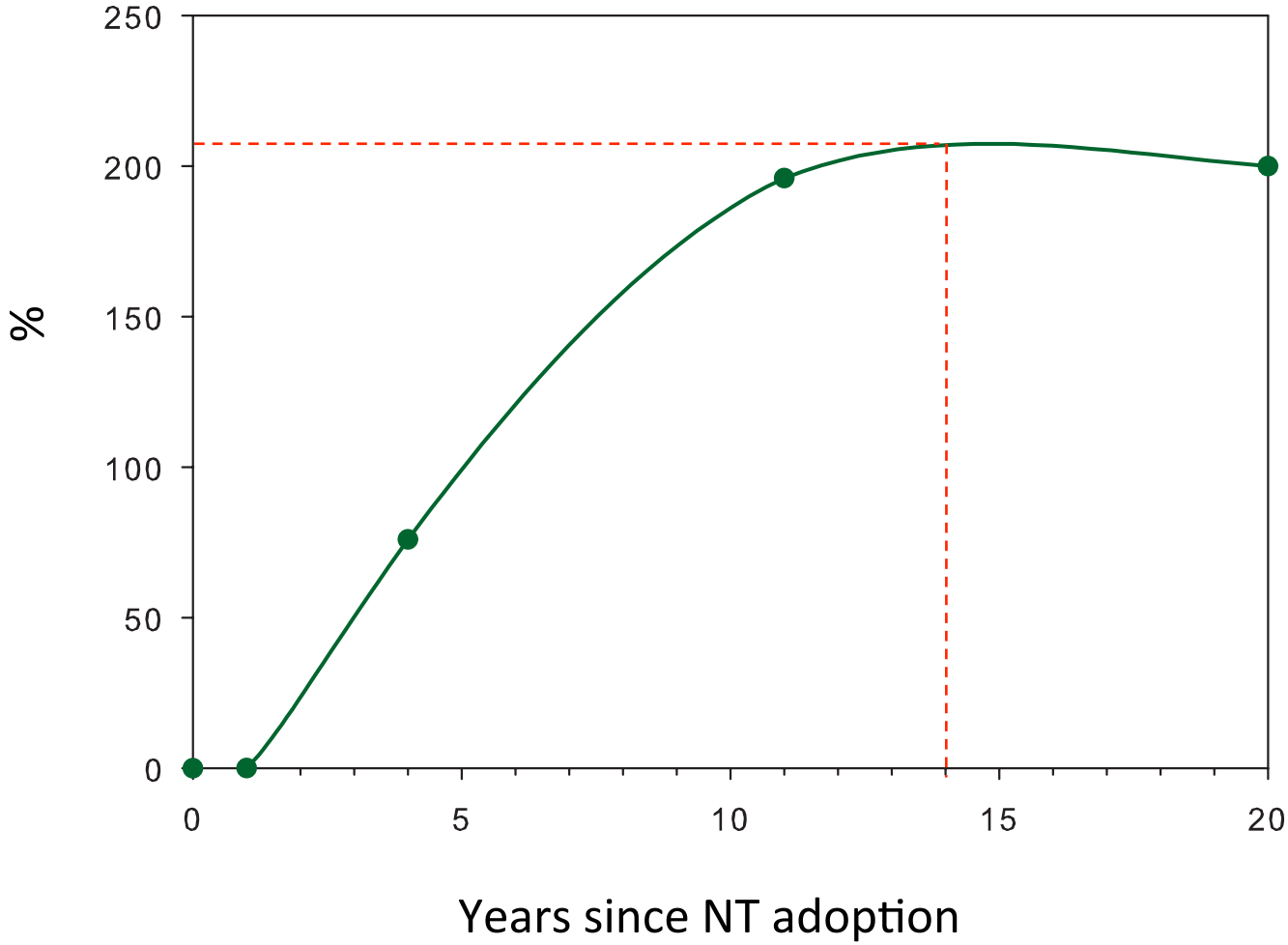
Soil depth (cm)	SOC stocks (Mg C ha^{-1})				
	0-NT	*1-NT*	*4-NT*	*11-NT*	*20-NT*
0-5	6.1 (0.2)^{b*}	6.3 (1.0)^{b}	10.1 (2.4)^{a}	12.3 (0.6)^{a}	12.1 (0.3)^{a}
5-10	6.0 (0.2)	5.4 (0.3)	6.7 (0.6)	7.8 (1.9)	7.3 (0.8)
10-20	10.7 (2.0)	12.4 (1.2)	9.6 (0.9)	9.6 (0.9)	12.0 (1.7)
20-30	10.2 (0.4)	9.1 (1.7)	8.7 (2.2)	8.0 (0.9)	7.4 (2.4)
0-30	**33.0 (0.7)**	**33.1 (1.1)**	**35.1 (1.9)**	**37.8 (1.3)**	**38.7 (1.6)**

* In parenthesis standard error. Means followed by the same lowercase letter within a row are not statistically different at $P \leq 0.05$ according to Tukey´s HSD mean separation test.

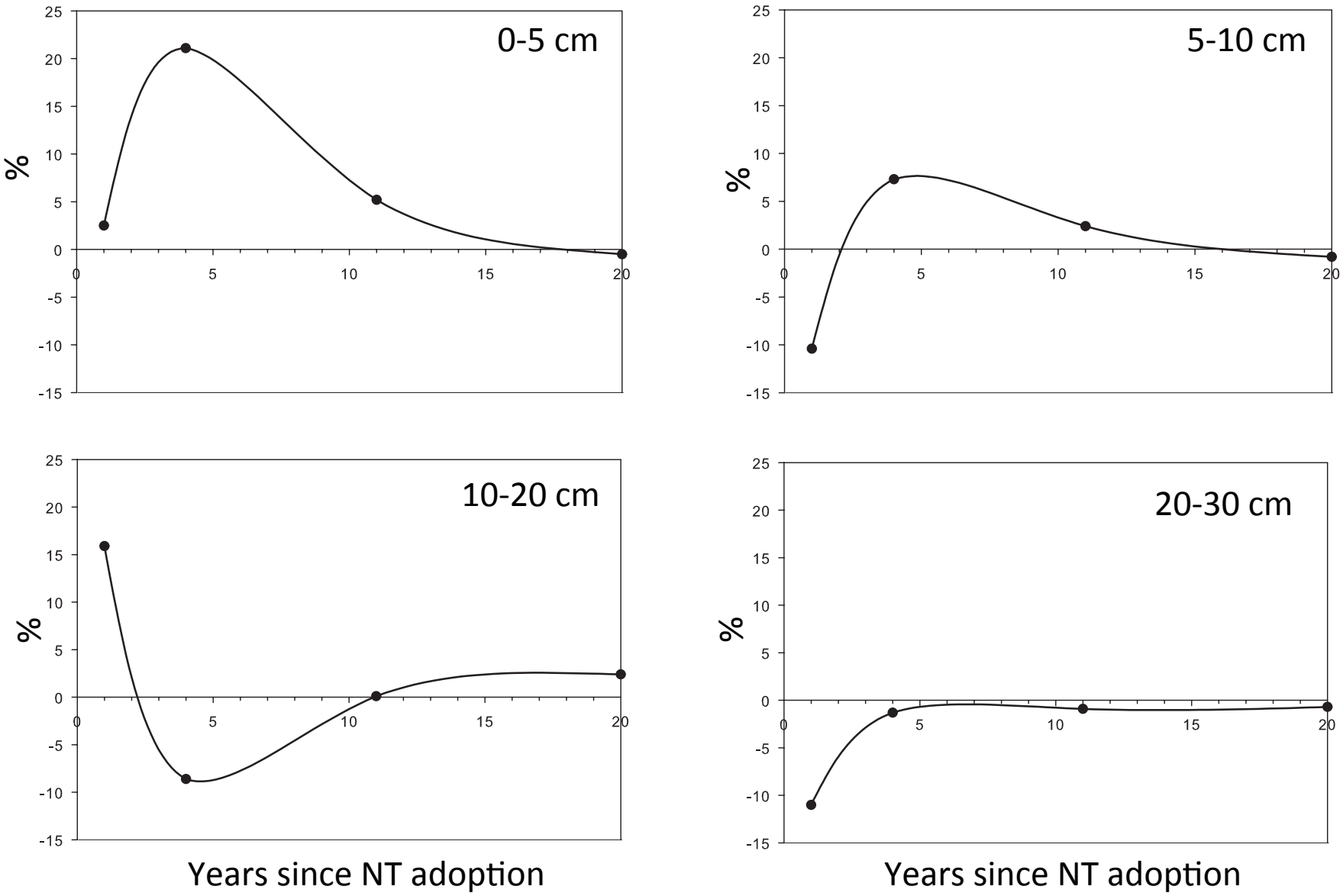
- Change in the annual amount of SOC sequestered



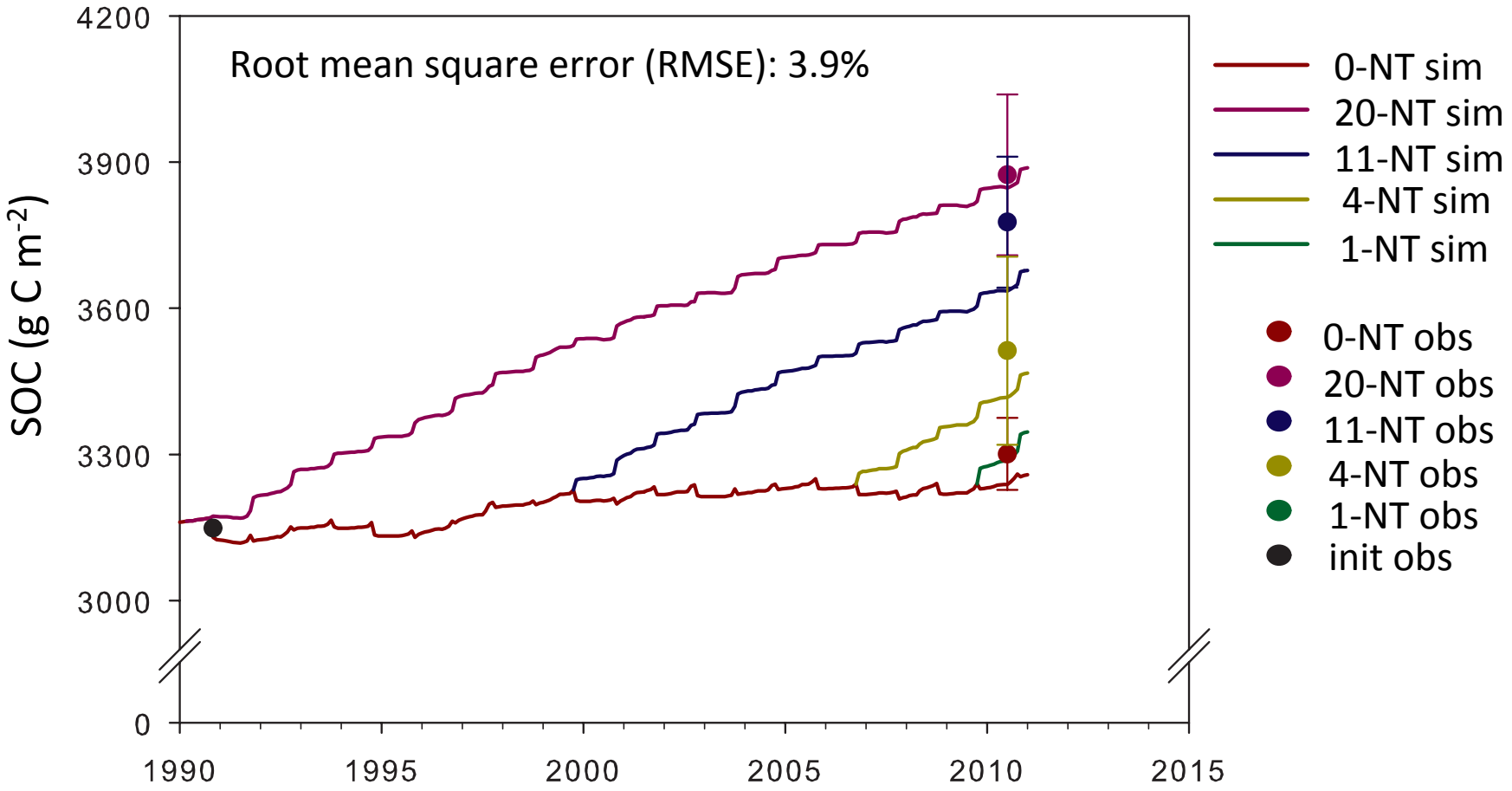
- Cumulative change in SOC sequestered



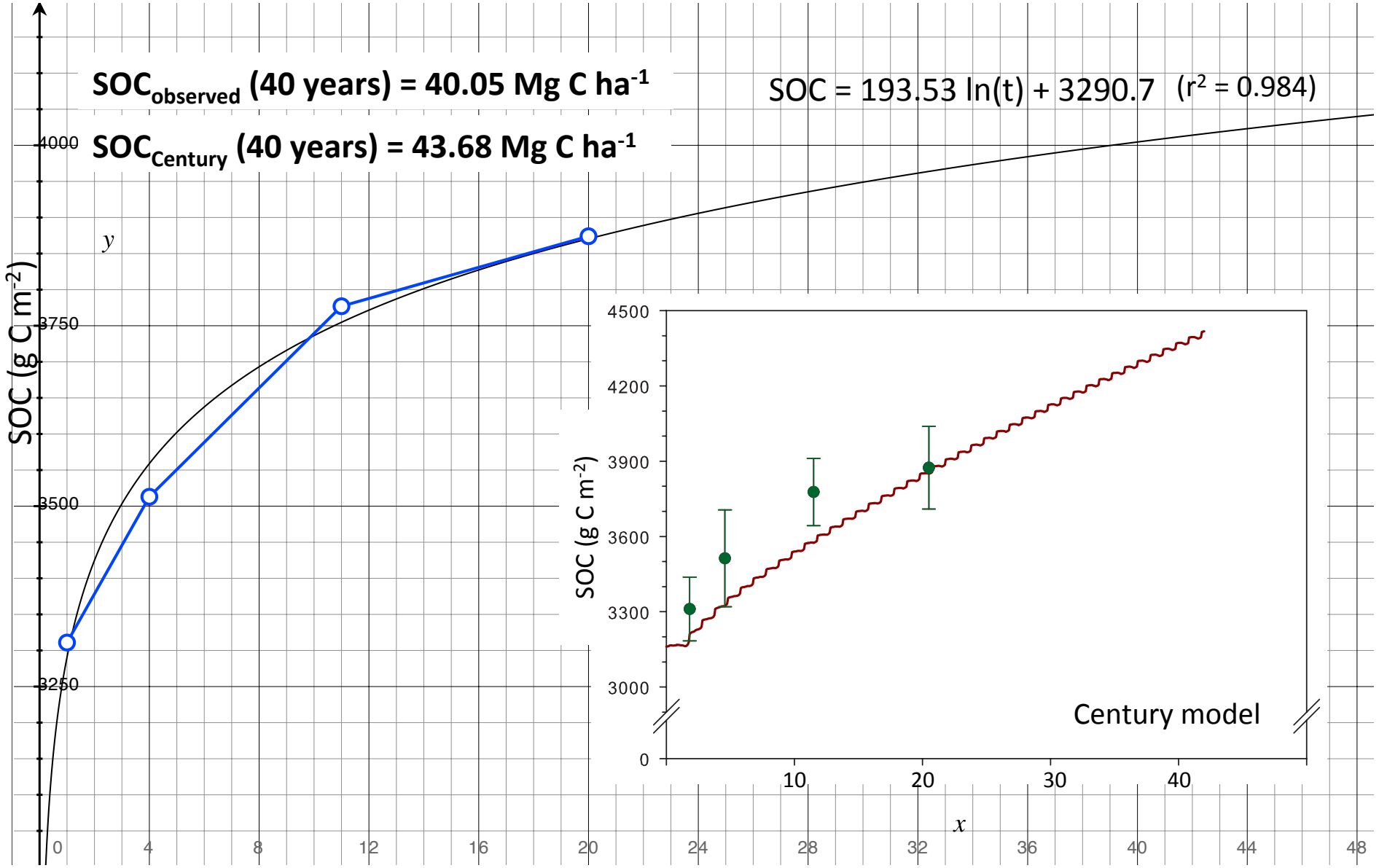
- Change in the annual amount of SOC sequestered by soil depth



- Chronosequence modelling



- Long-term scenario



CONCLUSIONS

In the Mediterranean agroecosystem studied,

- Compared to the initial SOC stock, NT sequestered up to 12% SOC in the first 30 cm soil depth

- The SOC sequestration duration was 14 years, with a maximum gain after 5-6 years from the adoption of NT

- The temporal dynamics of SOC sequestration varied with soil depth

- The Century C model slightly over predicted SOC stocks over the chronosequence

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